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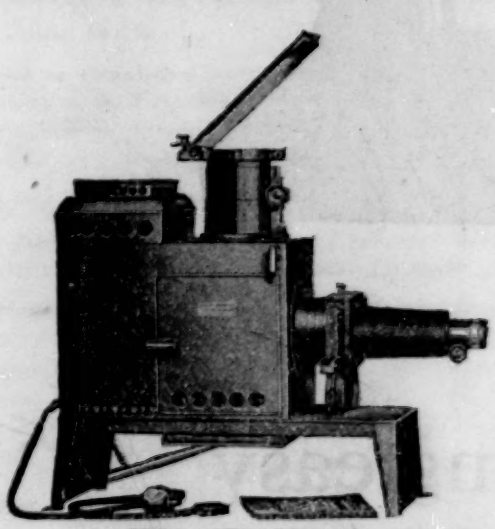

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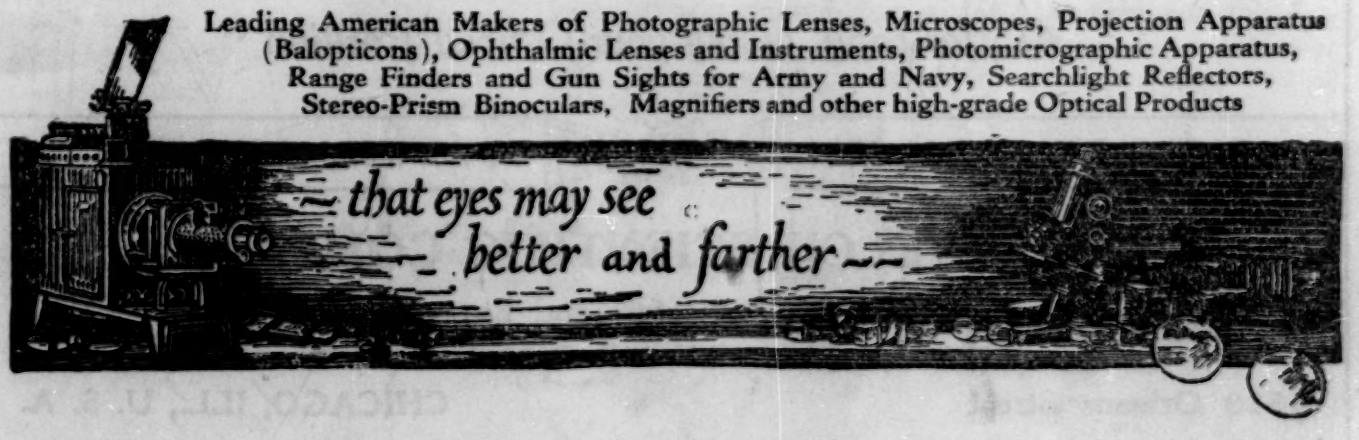

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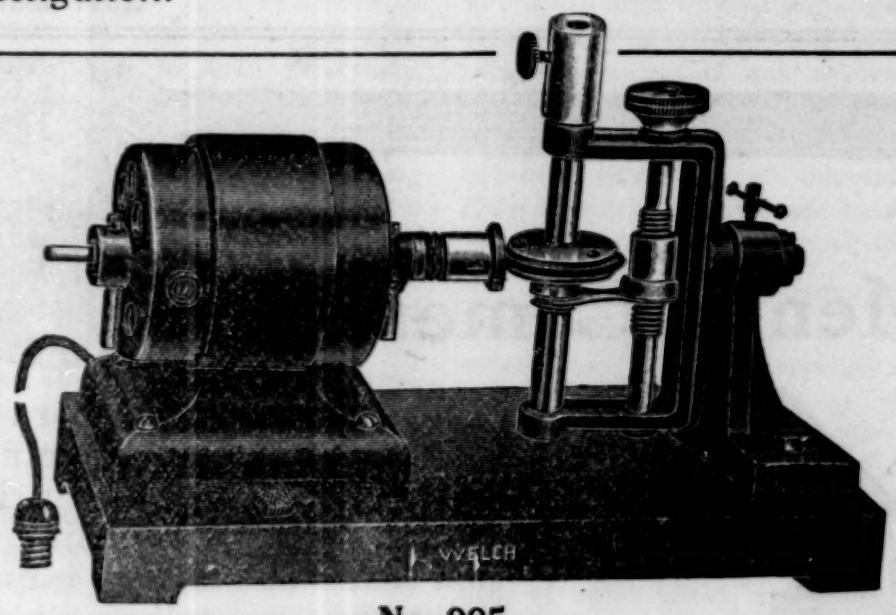

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THE SPECTROSCOPY OF THE EXTREME ULTRA-VIOLET[1]

In the year 1914 I published a monograph under the title of "The Spectroscopy of the Extreme Ultra-Violet"; to-day I wish to trace the progress of the subject to the present time. The part of the spectrum with which we are concerned has for its less refrangible limit wave-length 2,000 A.U.; it now extends to a region separated from X-rays by less than 200 units.

It is more than thirty years ago since Victor Schumann led the way into this undiscovered country, and gave his name to the region he explored. His methods and his results are familiar to all spectroscopists, but it may be well to remind you of the nature of the difficulties which he conquered. The extension of the spectrum in the ultra-violet is opposed by three factors, the opacity of the materials usually employed in the making of prisms and lenses, the opacity of gelatine, and the opacity of the air. By the use of fluorite, by the invention of a special photographic emulsion and by placing his spectrograph in vacuum, Schumann demonstrated that the spectrum could be extended by nearly eight hundred units.

The result, though easily described, was only reached after years of patient toil, for experimentation in this region was, and still is, beset with great difficulties. Every contribution which Schumann made to the subject is marked by the greatest exactness and finish; his field was limited, but within that field not only his technique but also his reasoning remain a model to this day.

The first and most characteristic product of his labors was a series of exquisite spectrograms of hydrogen; but owing to the lack of a dispersion curve for fluorite, it was out of the question to attach wavelengths to the lines

[1] Address of the president of the American Physical Society, Toronto, December, 1921.

which constituted these spectra. It was obvious that if a concave diffraction grating could be substituted for the prisms and lenses wavelength measurements could be made and at the same time the limitations set by the opacity of fluorite could be avoided.

I attacked the problem a good many years ago and most of the results have been long since in print. The spectrum of hydrogen was extended to the neighborhood of 900 units and its wavelengths were measured to within an error 0.2 of a unit, the accuracy being checked by Wolff through an ingenious application of certain series relations devised by Paschen. In a fruitless search for substances more transparent than fluorite the opacity of a large number of solids was next tested. The absorption of the commoner gases was measured and it was demonstrated that oxygen partly resumed its transparency with decreasing wavelength, a result which has been recently confirmed as we shall presently see. A considerable time was spent in the study of the emission of various substances and in the measurement of their spectra; partly because they occurred as impurities in the hydrogen discharge and partly because of the interest which attached to certain series relations connecting the radiations of some of them.

Toward the end of the period covered by these researches W. T. Bovie[2] of the Harvard Medical School became interested in the abiotic effects of Schumann rays, and carried out several investigations in that field. At nearly the same time F. H. Palmer[3] conducted a study of the volume ionisation produced by ultra-violet light; his experiments afford what I believe is the most direct proof of the effect yet obtained by any one. Later P. E. Sabine[4] carried out a preliminary investigation of the photo-electric effect in the region of very short wavelengths; and I. C. Gardner[5] made a quantitative study of the reflective power of metals and demonstrated the superiority of platinum and silicon over speculum in the extreme ultra-violet.

[2] *Botanical Gazette*, 59, No. 2, 1915; 60, No. 2, 1915; 61, No. 1, 1916, etc., etc.

[3] *Phy. Rev.*, 32, p. 1, 1911.

[4] *Phy. Rev.*, N. S. 9, p. 210, 1917.

[5] *Astrophysical J.*, 45, p. 30, 1917.

Having completed a reconnaissance of the region discovered by Schumann it was natural that attention should turn to its extension toward the ultra-violet. By the use of helium gas and by the employment of a strong disruptive discharge I succeeded in pushing the spectral limit to the neighborhood of 500 AU in 1917.[6] In the process of this research various gas spectra including those of argon and nitrogen came under observation; moreover, the existence of the series in hydrogen predicted by Ritz and obeying the law $V = N\left(1 - \frac{1}{m^2}\right)$ was confirmed.

During the period whose activities have so far been described interest in the Schumann region had been confined to a very few, and the work had been carried on in but a limited number of places. We now enter on an epoch extending to the present time, where the study of this field bids fair to be much more general. In view of this awakening interest it may be well to pause long enough to say something of the technique which is involved in the study of the spectral region under discussion.

The spectroscopy of the extreme ultra-violet combines all the difficulties inherent in the nice adjustment of delicate optical apparatus with those which accompany the production and maintenance of high vacua in metallic containers of large volume. The first are only to be overcome by skill and patience; the second have been greatly alleviated during recent years by the improvement in mechanical vacuum pumps and by the use of charcoal and liquid air. In the design of the vacuum spectroscope, whether it be intended for prism or grating, simplicity is the chief requisite. This I was at some pains to point out years ago. A good example is afforded by the highly successful apparatus of Millikan where grating, plate holder and source are all contained in one cylindrical brass tube closed at the ends by simple plates made air tight with rubber gaskets. The improvements which McLennan has introduced have also been directed away from the pernicious ingenuities of the instrument makers.

[6] *Astrophy. J.*, 43, p. 89, 1916.
SCIENCE, 45, p. 187, 1917.

Time does not permit the discussion of details of design but it is useful to note that McLennan has emphasized the advantage of horizontal surfaces for those joints which must be often made and broken; I venture to add that I still find the gasket formed of a string of soft wax useful in such joints even when the highest vacuum is required. Moreover, I have found that a carefully cut screw of say ½ mm. pitch working in a nut about 6 cm. long will serve to communicate motion to electrodes within the apparatus without introducing a leak provided the screw and nut are sealed together with wax after each adjustment.

There is one fault in vacuum spectroscope design so common that it merits particular attention. It is concerned with the question of angular aperture in those cases where a lens cannot be employed. For example, if the slit is placed on the circle whose diameter is the grating's radius of curvature, and to which the plate should conform, it is mechanically difficult to place the source of light sufficiently near the slit to fill the grating. Millikan has overcome the trouble, as we have just seen, by placing the source of light within the body of the spectroscope, but this process presents some inconveniences when vacuum tube spectra are to be examined.

The grating affords the only means at our disposal for analyzing light of the very shortest wave lengths spectroscopically, but its use is accompanied by several disadvantages, not the least of which arises from the fact that an amount of tarnish which would be quite harmless in the ordinary part of the spectrum proves fatal in the region under discussion. To the favored few who have a ruling engine at their command the difficulty is overcome by the simple expedient of ruling a new grating! The majority are not so fortunate, they may therefore be interested in the results of some experiments of my own. Guided by the work of Gardner, I have tried covering a tarnished grating with a thin cathode deposit of either platinum or silicon. The results seem favorable and I have good hopes that the method affords a means of rejuvenating diffraction gratings especially if silicon be employed.

We may now return to a consideration of the results of the last half dozen years. In 1914, Saunders,[7] working at Tübingen, followed the spectra of calcium and zinc in a vapor lamp to the neighborhood of 1000 A.U. He also confirmed my observations on the hydrogen lines of the Ritz series.

About the same period L. and E. Bloch[8] began their investigations; their work, interrupted by the war, has recently been resumed. Their vacuum spectrometer contains a train of fluorite and includes the novel feature of a constant deviation prism. They have measured the spark spectra of sixteen elements, to the neighborhood of 1400 A.U. Their tables contain not only their own results but also those of other investigators in the same field. The determinations of wavelength rest on my values for certain lines in aluminium, hydrogen, mercury and nitrogen. It may be noted parenthetically that wherever possible a direct comparison with the spectrum of hydrogen should be used in measurements between 2000 and 1000 A.U.

McLennan,[9] in collaboration with his students, has measured both the arc and spark spectra of a considerable number of substances. He has employed both prism and grating instruments and with the latter he has pushed his results to the neighborhood of 500 A.U. His researches have emphasized the importance of the suppression of water vapor in the spectroscope; to this end he has added ample drying tubes to his apparatus. It is particularly interesting to note that he has succeeded in obtaining radiations down to the neighborhood of 1020 A.U. through an atmosphere of helium over two meters long at a pressure of 29 cm., thus confirming the transparency of the gas in the Schumann region.

His most recent work revives the discussion as to the existence of the series in helium corresponding to the formula $V = 4N\left(\frac{1}{2^2} - \frac{1}{m^2}\right)$. I have presented[10] some evidence for the existence of the two first mem-

[7] *Astrophy. Jour.*, 40, p. 377, 1914.

[8] *Jour. d. Phy. et le Radium*, 2, p. 229, 1921.

[9] Proc. Roy. Soc., 95, p. 258, 95, p. 316, 1919; 98, pp. 95-123, 1920.

[10] SCIENCE, 50 p. 481, 1919.

bers, but I must confess that I am not altogether satisfied with its validity. As to the members of higher order adequate proof of their existence seems to be quite lacking. The crux of the whole matter lies in the fact that to produce radiations of sufficiently short wave length a violent disruptive discharge must be employed which introduces impurities torn from the discharge tube and its electrodes. No matter how carefully the gas is treated the lines due to these impurities furnish a constant source of confusion which must never be overlooked. In spite of the fascinating possibilities conjured up by the work of Rutherford on atomic disintegration, I am of the opinion that but three lines can be ascribed to the spectrum of helium in the Schumann region with any certainty. Of these two lie near 1640 and 1215 A.U. and are by no means above suspicion. The origin of the third at 585 discovered by Fricke[11] and the speaker last year is much more to be relied upon. This last radiation possesses the added importance of showing a direct numerical relation with the radiation potential of helium.

I have said that interest in our subject is spreading. As evidence I present some very recent results obtained on the Pacific Coast by J. T. Hopfield. He has devised a method of studying the emission spectra of gases which are opaque in the Schumann region without the use of a window, the transparent gas which fills the body of the spectroscope and the substance under examination being kept separate by gas currents suitably directed. One of his most striking results relates to the spectrum of oxygen; he not only finds a number of lines throughout the Schumann region which he attributes to this element, but he has also discovered that radiations between wavelengths 1336 and 990 may be photographed even through a column of oxygen a meter long and at a pressure of about 0.4 mm. This result confirms and extends my observations on the absorption band of this gas. Finally, he appears to have discovered an improved process for the manufacture of Schumann plates.

[11] *Phil. Mag.*, 41, May, 1921.

By far the most important contribution to the subject has been made by Millikan.[12] Ably seconded by his students, Sawyer and Bowen, he has not only succeeded in extending the spectrum to the neighborhood of 150 A.U. but also by the study of the radiations in this region he has established a connection between light diffracted by a grating and those shorter wavelengths known as X-rays. Rightly conjecturing that the production of vibrations of the highest frequency depends as much on the intensity of the electric field at the source as upon the substance of the radiator, he has employed a minute high potential spark in the best obtainable vacuum. With this arrangement he has investigated the spectra of a number of substances including carbon, zinc, iron, sodium, magnesium and aluminium and has measured many of their lines.

It is a curious fact that many substances produce spectra of striking similarity in the extreme ultra-violet when stimulated by the high potential spark or even when exposed to a disruptive discharge in a vacuum tube. The lines of the spectrum obtained from helium, for example, are nearly all common to the spectra of carbon and of lithium, while aluminium, magnesium and iron, etc., have identical spectra between 1000 and 250 A.U. The presence of a common impurity furnishes the most conservative explanation for this striking phenomenon, though those inclined to speculation may turn a longing eye toward atomic disintegration. Millikan[13] has shown that oxygen is probably the impurity in question.

Fabry[14] has recently emphasized the fact that this region of roughly 150 A.U. between the limit as set by Millikan's experiments and X-rays capable of analysis by a crystal is one of the most interesting in the whole spectrum. He points out that here the absorption of many substances should pass through a maximum and then decrease; here metals begin to manifest their high reflective power and here the phenomena of refraction will appear,

[12] *Astrophy. Jour.*, 52, 47, 1920; 52, 286, 1920; 53, 150, 1921.

[13] Proc. Nat. Acad., 7, p. 289, 1921.

[14] Journal Franklin Institute, p. 227, 1921.

though probably masked by absorption. The exploration of this region by methods not strictly spectroscopic lies beyond the scope of this paper but the subject is so fascinating that I cannot resist a brief digression.

The production and study of very soft X-rays has occupied the attention of many investigators here, in England and on the continent. One of the researches typical of the early development of the subject was that of Sir J. J. Thomson[15] in 1914; one of the more recent is that of Halweck.[16] As the method of this second investigator seems to trace a rather direct path across the frontier of the extreme ultra-violet it merits our attention.

Halweck generated his soft X-rays in a Coolidge tube of special form separated from an ionisation chamber destined to measure the absorption cofficients of the radiations by an extremely thin window of celluloid. He observes that the absorption coefficient of gases increases with wavelength between 40 A.U. and 100 A.U. following an exponential law similar to that observed by Owen for ordinary X-rays. For celluloid the coefficient at first follows the same law, then increases less and less rapidly, passes through a maximum near 320 A.U. and diminishes toward the ultra-violet. This work is of particular interest since it traces a physical property of a solid, its absorption, through the "no man's land" in question. All estimates of wave length are obtained from the potential difference in the tube and the use of the relation $Ve = hv$.

Holweck finds that a film of celluloid a quarter of a micron thick transmits about twenty per cent. near 1000 A.U., while but three per cent. will pass at the maximum of absorption, this result is of some practical importance to the spectroscopist. Miss Laird[17] has also made a preliminary investigation on the transmission of thin membranes.

The study of radiation and ionisation potentials affords another means of bridging the gap between optical spectra and X-rays. Begun by Franck and Hertz, and continued by many investigators here and abroad with results of such fundamental importance, work in this field has led Mohler and Foote[18] to the discovery of characteristic soft X-rays produced by arcs in vapor. They interpret their results to mean that the critical potentials which they have measured correspond to the first L absorption lines of X-ray spectra of the substances in question: for if the square roots of the frequencies, computed from these potentials, be plotted on a Moseley diagram, the points will be very nearly on a continuation of the straight line typical of the L X-ray spectra of the heavier elements. The longest wavelength they have measured in the L series is for sodium, 353 A.U., magnesium yielding 268, and phosphorus 98. A critical potential for potassium is interpreted as an M series limit with a wavelength of 536 A.U.

When we return to purely spectroscopic investigation we find that the most striking results have been recently obtained by Millikan.[19] In an address before the National Academy, in April, he reports the discovery of certain lines of aluminium, magnesium and sodium at 144.3, 232.2, and 372.2 A.U., respectively, which he identifies as the $L\alpha$ lines of the X-ray spectra of these elements. The square roots of the corresponding frequencies lie very nearly on the straight line connecting $L\alpha$ frequencies and atomic number on the Moseley diagram. The wavelength of the $L\alpha$ line for sodium is in qualitative agreement with the value found by Foote and Mohler; for aluminium and magnesium, however, the case is not so clear. As Duane has pointed out the difficulty arises in this way: it is a fundamental property of X-ray spectra that the $L\alpha$ line lies on the long wavelength side of the L absorption; now the L absorption for aluminium and for magnesium can be accurately calculated; they lie at 173 and 257 respectively, but the $L\alpha$ lines for these substances chosen by Millikan are at 144.3 and 232.2. Thus the values are on the wrong side of the position of absorption.

The spectra of aluminium, magnesium and sodium occupy but a very limited region in

[15] *Phil. Mag.*, 28, p. 620, 1914.
[16] *Comptis Rendu*, 171, p. 849; 172, p. 439.
[17] *Physical Rev.*, 15, 543, 1920.
[18] *Jour. Wash. Acad.*, 11, p. 273, 1921.
See also Kurth, *Phy. Rev.*, 17, 528, 1921.
[19] Proc. Nat. Acad., 7, 289, 1921.

the extreme ultra-violet and there is a considerable blank before their lines reappear in the Schumann territory. It is of interest to inquire if these spectra present that similarity of structure which is a fundamental characteristic of X-ray spectra of the heavier elements.

The nature of modern atomic models might lead one to expect certain rather abrupt changes with decreasing atomic number in the appearance of spectra of elements lighter than Neon. These changes Millikan has observed. He attempts to bring these spectra under the X-ray classification by arbitrarily designating certain lines as the $L\alpha$ radiation of the corresponding substances. The wisdom of this course seems to me somewhat doubtful, for though there is probably no discontinuity between the mechanism which produces optical spectra and that to which the X-rays owe their origin, yet the structure of spectra of the lighter elements seems to resemble the arrangement of X-rays so little that the same nomenclature cannot be employed in both cases with profit. Even where the radiating mechanism is simple as in hydrogen, there is small advantage in calling the Ritz series a K series or in designating the Balmer series as an L series. However, this objection is only a matter of taste; certainly it in no way detracts from the importance to be attached to Millikan's discovery, for by purely spectroscopic methods he has made a most important advance on the road connecting the region of X-rays with the rest of the spectrum.

Thus we see that the extreme ultra-violet has grown from an obscure corner of spectroscopy to a region of real importance, and that its study has developed from a scientific tour de force into investigations intimately connected with the most fundamental matters.

And now, before I close, let us look back over these thirty years to the man who began it all; *Victor Schumann*, slow, exact, infinitely patient, without any brilliant generalizations in his head but absolutely sound in his conclusions. Perhaps even the atom builder may pause a moment to contemplate him, and may profit by the process.

Theodore Lyman

Harvard University

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

REPORT OF THE COMMITTEE[1] ON AN INTERNATIONAL AUXILIARY LANGUAGE ACCEPTED BY THE COUNCIL AT TORONTO, DECEMBER 29, 1921

The present report makes no attempt to discuss what might be the detailed requirements of an international auxiliary language, nor even to consider alternative solutions already suggested. The committee has interpreted its immediate function as in no sense that of a judge to pass on such matters or even to assemble them for critical review at present, but it aims simply to present herein as concise and constructive a view as possible of the present state of public interest in the problem and to recommend what should be the attitude and activities of the association with respect to serious studies in this whole field, leaving it entirely to the results of such studies, if undertaken, to speak for themselves.

The subject of international language is an old one and a great deal of effort has already been expended upon it, but chiefly by individuals or by organizations formed purely for this purpose. It is only in the last few years that there has been any general movement on the part of governmental, scientific or academic bodies to take the subject seriously and follow it systematically.

The present organized movement in this direction may conveniently be considered as dating from the adoption by the International Research Council in July, 1919, at Brussels, of the following resolutions:

(*a*) That the International Research Council appoint a committee to investigate and report to it the present status and possible outlook of the

[1] Authorized by the Council at St. Louis, December, 1919, and appointed April, 1921: S. W. Stratton (chairman), director, United States Bureau of Standards; Carl L. Alsberg, director, Food Research Institute, Stanford University; V. A. C. Henmon, professor of education and director of School of Education, University of Wisconsin; John C. Merriam, president, Carnegie Institution of Washington; C. E. Seashore, professor of psychology and dean of the Graduate College, University of Iowa.

general problem of an international auxiliary language.

(*b*) That the committee be authorized to cooperate in its studies with other organizations engaged in the same work, provided that nothing in these resolutions shall be interpreted as giving the committee any authority to commit the council to adhesion to or approval of any particular project.

The activities of the committee appointed under these resolutions have thus far been devoted chiefly to awakening interest and securing cooperation through the national scientific, academic, educational, technical and commercial organizations of the individual countries, it being felt that a broad and intelligent interest in the subject within these national academies, societies and associations is a necessary prerequisite to any effective international action toward practical results.

Since the creation of the above-named committee a number of other important public bodies have taken definite action looking in the same general direction. Thus, on September 13, 1921, the following resolution was presented in the Assembly of the League of Nations by delegates representing twelve states:[2]

The League of Nations, well aware of the language difficulties that prevent a direct intercourse between the peoples, and of the urgent need of finding some practical means to remove this obstacle and help the good understanding of nations;

Follows with interest the experiments of official teaching of the international language Esperanto in the public schools of some members of the League;

Hopes to see that teaching made more general in the whole world, so that the children of all countries may know at least two languages, their mother tongue, and an easy means of international communication;

Asks the Secretary General to prepare for the next Assembly a report on the results reached in this respect.

[2] Lord Robert Cecil (South Africa), Jonnesco (Rumania), Emir Zoka-Ed-Dovleh (Persia), La Fontaine (Belgium), Benes (Czecho-Slovakia), Restrepo (Colombia), Tsai Fou Tang (China), Enckell (Finland), Fan Noli (Albania), Adatei (Japan), Escalante (Venezuela), Maharajah Knengarje (India), Askenazi (Poland).

The special committee[3] dealing with the inclusion on the agenda, of motions submitted to the Assembly reported to that body on September 15, 1921, with regard to this motion, as follows:

The above-mentioned delegates have proposed the introduction of Esperanto, as an auxiliary international language, into public schools, in order to facilitate direct intercourse between all nations throughout the world.

The committee are of opinion that this question, in which an ever increasing number of great states are interested, should be attentively studied before it can be dealt with by the Assembly. The question was referred to a committee last year and a short report was submitted, recommending that the Secretariat of the League should investigate the experiments already made and ascertain the actual results attained.

The committee proposes *that the question should be placed on the agenda of the next Assembly* and that the Secretariat of the League should in the meantime prepare a complete report, accompanied by the necessary documentation, on the lines indicated in the draft resolution.

In accordance with the wishes of the signitories, the Report of Committee No. 2 (document 253, of December 17, 1920) and the Report of the Under-Secretary-General upon his mission to the Congress at Prague will be transmitted to the members of the League in due course.

This report by the Under-Secretary-General (Dr. I. Nitobe) referred to above, consists of three sections, viz.: (I) An Account of the Thirteenth International Congress of Esperantists at Prague, July-August, 1921; (II) Observations on the Esperanto Movement; (III) The Language Question and the League of Nations. Nearly the complete text of the last section was printed and distributed to delegates during the last Assembly, as document A 72, 1921, XII, 14 Sept., 1919, copy of which is hereto attached as Appedix A.[4] The whole report will undoubtedly be available later.

The first national scientific body to take up

[3] Lord Robert Cecil (South Africa), *chairman;* Restrepo (Colombia); Schanzer (Italy); Tang Tsai Fou (China); de la Torriente (Cuba); Trygger (Sweden); Viviani (France).

[4] Copies of these appendices may be secured through the National Research Council, 1701 Massachusetts Avenue, N. W., Washington, D. C.

the question seriously was the British Association for the Advancement of Science, which, in response to the call of the International Research Council, appointed, through its section on Educational Science at its Bournemouth meeting, September, 1919, a committee "to Enquire into the Practicability of an International Auxiliary Language." At the Edinburgh meeting, September, 1921, this committee presented a comprehensive report of its studies to date, covering chiefly comparisons of Latin, as typifying classical languages; English, as typifying modern languages; and Esperanto and Ido, as typifying the artificial group. The committee briefly summarizes its conclusions as follows:

(1) Latin is too difficult to serve as an international auxiliary language;

(2) The acceptance of any modern national language would confer undue advantages and excite jealousy;

(3) Therefore an invented language is best. Esperanto and Ido are suitable but the committee is not prepared to decide between them.

The committee was continued and is understood to be making a more detailed study of artificial languages. The 1921 report of the committee is hereto appended as Appendix B.[4]

During the past year both the French and the Italian Associations for the Advancement of Science have likewise appointed committees on the international language question, but as yet these committees have made no reports.

Experiments in the teaching of Esperanto abroad, as a regular subject in the public school curriculum, are rapidly multiplying and being taken more seriously. This last year, for example, it was introduced as an optional subject in all the public schools of Milan, Italy, in the eighth year, being actually taken by some 2,000 students, while it has been made a compulsory subject for the present school year in all of the public schools of Geneva, Switzerland, for the seventh year of the course, representing some four hundred students. A brief published account of similar experiments in the north of England is herewith included as Appendix C.[4] Chambers of commerce and labor organizations are also showing a steadily growing interest in the matter, as more fully outlined in Dr. Nitobe's report (Appendix A.)

In the United States, the following academic bodies have already appointed committees on the subject: American Association for the Advancement of Science, American Council on Education, American Classical League, American Philological Association, National Research Council. The American Council of Learned Societies has authorized the appointment of delegates to confer with the last-named committee in an attempt to work out a plan of cooperation between the two councils. This seems of paramount significance because of the position which these two councils occupy as the American representatives, respectively, of the International Research Council and the International Union of Academies, which latter two organizations constitute the recognized international authorities in natural science, on the one hand, and in humanistic studies, on the other.

It is interesting in this connection to note that the initiative in the present question seems to have come from the natural scientists, chiefly out of their interest as prospective users of such a language, although they have indicated throughout that they clearly recognized the technical side of the question to lie squarely in the proper field of the linguist, to whom they turn for help, much as the engineer and manufacturer have in the past turned to the worker in pure science, insisting that he help them in their practical needs with his expert knowledge from the theoretical side, even though their so-called applied science might not attract him as an aim in itself.

It seems to your committee that, to attain useful practical results in this subject, two things are essential:

First, a searching fundamental study of the principles involved and experimental data available;

Second, authoritative international agreement, both as to linguistic details and as to the practical measures to be taken.

In certain general aspects of the first requirement, members of the American Association may be of direct assistance, as, for instance, the physicist, in the recording and analysis of the sounds in speech, and the psychologist, in the measurement of mental phenomena. Also, in each special field of science and technology,

the working out of technical vocabularies will call for close cooperation of all concerned. But we must naturally look to the linguist and the philologist for the greater part of the general framework of fact and interpretation. However, it is just in such new frontiers of knowledge that thorough and intimate cooperation by all groups is most apt to be fruitful.

With regard to the second requirement, the American Association may make its influence most potently felt through vigorous moral support of the project in general, and especially of the leadership of the work by the two national councils above mentioned, as the logical path for expression of natural academic thought in the international field.

In order to give expression to the position of the association on this general problem your committee recommends the adoption of the following resolutions:

WHEREAS, All the sciences are alike interested in unifying the fundamental tools of thought, and have been notably successful in so doing, with respect to our system of numbers, the Arabic numerals, the metric system, the measurement of latitude and longitude, angular divisions, mathematical symbols, chemical formulæ, time and the calendar, notation in music, and other technical usages; and

WHEREAS, There appears to be a generally expressed need for a suitable international auxiliary language for the prompt and world-wide diffusion of scientific data, and for intercommunicating between nations differing in languages;

THEREFORE, BE IT RESOLVED, That the American Association for the Advancement of Science:

(*a*) Recognizes the need and timeliness of fundamental research on the scientific principles which must underlie the formation, standardization, and introduction of an international auxiliary language, and recommends to its members and affiliated societies that they give serious consideration to the general aspects of this problem, as well as direct technical study and help in their own special fields wherever possible;

(*b*) Looks with approval upon the attempt now being made by the National Research Council and the American Council of Learned Societies to focus upon this subject the effort of those scholars in this country best fitted for the task, and to transmit the results to the appropriate international bodies;

(*c*) Indorses the heretofore relatively neglected problem of an international auxiliary language as one deserving of support and encouragement;

(*d*) Continues its Committee on International Auxiliary Language, charging it with the furtherance of the objects above enumerated and reporting progress made to the association at its next meeting.

S. W. STRATTON,
Chairman

THE PSYCHOLOGICAL CORPORATION[1]

THE Psychological Corporation has been incorporated under the laws of the State of New York. The second article of the charter reads:

The objects and powers of this corporation shall be the advancement of psychology and the promotion of the useful applications of psychology. It shall have power to enter into contracts for the execution of psychological work, to render expert services involving the application of psychology to educational, business, administrative and other problems, and to do all other things, not inconsistent with the law under which this corporation is organized, to advance psychology and to promote its useful applications.

So far as is known, this is the first corporation organized under the provisions of the business corporation laws of any state whose objects are the advancement of science and whose earnings must be devoted to scientific research. There are, of course, membership and charitable corporations not for profit and exempt from taxation, but the Psychological Corporation proposes to earn by its services the money that it will use for psychological organization and research.

Further provisions of the charter provide that no dividend in excess of $6 per share shall be paid during any calendar year and empower the American Psychological Association to take over any or all of the stock on payment of $100 per share. The stock is held in the first instance by psychologists active in the work of the corporation. It may be noted

[1] Statement prepared by the president of the Psychological Corporation.

that the general form of organization would be desirable for any public service corporation.

The directors of the Psychological Corporation are:

James R. Angell, Yale University.

W. V. Bingham, Carnegie Institute of Technology.

J. McKeen Cattell, The Psychological Corporation.

Raymond Dodge, Wesleyan University.

S. I. Franz, Government Hospital for the Insane.

G. Stanley Hall, Clark University.

H. L. Hollingworth, Barnard College, Columbia University.

Charles H. Judd, University of Chicago.

William McDougall, Harvard University.

W. B. Pillsbury, University of Michigan.

Walter Dill Scott, Northwestern University.

C. E. Seashore, University of Iowa.

Lewis M. Terman, Stanford University.

Edward L. Thorndike, Teachers College, Columbia University.

E. B. Titchener, Cornell University.

Howard C. Warren, Princeton University.

Margaret Floy Washburn, Vassar College.

John B. Watson, The J. Walter Thompson Company.

R. S. Woodworth, Columbia University.

R. M. Yerkes, National Research Council.

The Psychological Corporation proposes to maintain adequate standards in applied psychology, to assure opportunities and proper payment to those competent to do the work, and to use the profits for psychological research.

Psychology, owing to its recent progress and war service, is attracting wide public attention. This publicity is being used for all sorts of schemes, some of which may seriously injure psychology, not only in its applications but also in its academic standing. It is desirable that the general public shall have some means of learning what psychology can and what it can not do, and who can and who can not do it. An organized group of psychologists, whose standing is recognized, can exert a useful influence at the present time.

There is much psychological work of economic value that might at present be undertaken to advantage and there are those competent to do the work, but no satisfactory method exists for bringing them together. It is desirable to extend the work and especially to obtain a larger number of able workers and to provide more adequately for those who take up psychology, whether as an independent profession or in universities and other institutions.

The support of research work in any science has always been a difficult problem. In the past such work has been carried forward mostly by those earning their living by teaching. The industrial laboratories are now helping to improve the situation in chemistry, physics and the medical sciences; men are being engaged at relatively large salaries to do research work, often without direct reference to its useful applications. If research in psychology can be supported as a by-product of economic service, its progress will be accelerated in a geometrical ratio.

Perhaps the greatest opportunity is the investigation of problems directly or indirectly of economic value to individuals or groups, of which the work in industrial chemistry of the Mellon Institute of Pittsburgh is an example. Some seventy fellows, mostly younger men, paid an average salary of about $3,000, are engaged in research on problems of use to manufacturing chemists. The Psychological Corporation proposes to use the existing laboratories, where the special work can be done to the best advantage and thus to assist the universities and their psychologists.

The problem of selection for general intelligence and for special aptitudes or training is one in which psychology can be of great service at the present time. If standard tests are developed to be used everywhere, both among employees in groups and with individuals seeking employment or advancement, the corporation can give useful employment to many psychologists and probably earn sufficient income to carry on its work, and by research improve and standardize the tests.

The central offices of the Psychological Corporation are in the Grand Central Terminal, New York City. Branches have been established, or are in course of establishment, in Washington, Boston, Pittsburgh, Chicago, San Francisco and other centers. The real work

of the corporation will, however, be done by psychologists in existing laboratories.

At the first meeting of the directors the following officers were elected:

President: J. McKeen Cattell.
First vice-president: Walter Dill Scott.
Second vice-president: Lewis M. Terman.
Chairman of the board: Edward L. Thorndike.
Secretary and Treasurer: Dean R. Brimhall.

SCIENTIFIC EVENTS

LIST OF SCIENTIFIC PERIODICALS[1]

THE Conjoint Board of Scientific Societies (Burlington House, London, W. 1) proposes to provide a world list of periodical publications which contain the results of original scientific research. It is hoped that it will be possible to give in a single octavo volume the titles, in alphabetical order, and the places of publication of all such periodicals in existence on January 1, 1900, and of all issued after that date. The libraries in London, Oxford, Cambridge, Edinburgh, Dublin, and Aberystwyth, which take in such periodicals, would be indicated, and, wherever possible, at least one library in the United Kingdom would be mentioned for each periodical. The scheme aims at supplying a complete list of current scientific periodicals; and, if means are found to carry it out, may form a basis of cooperation between libraries, so that both the number of duplicates and the list of periodicals not received may be reduced. The trustees of the British Museum have consented to allow the compilation of the list to be undertaken by the staff of the Museum, and already a large bulk of material has been collected in the museum by various societies and by the conjoint board. The Museum, however, can not undertake to defray the cost of printing and publication, but it is hoped that a sufficient number of libraries and institutions will agree in advance to purchase one or more copies at the price of 2 guineas each. The preliminary announcement which has been issued does not attempt to define a scientific periodical, but we apprehend that it is intended to exclude technical publications. It is not clear whether periodicals devoted to medicine would be included, and we understand that the point has not yet been decided. All departments of medicine, hygiene, and pathology, however, suffer more or less from the difficulty described, but it is felt to a very special degree by workers in these subjects in their application to the tropics; in particular the literature on helminthology, and indeed on parasitology generally, is very scattered, and papers which turn out to be of importance may be published in out-of-the-way periodicals, in the transactions of local societies, or in periodicals primarily devoted to some other science, as for instance entomology. Some time ago Professor R. T. Leiper, Director of the Department of Helminthology at the London School of Tropical Medicine, suggested that a list, showing the libraries in London and Liverpool at which periodicals publishing papers on tropical medicine could be consulted, would be of great use to workers, who at present may waste much time in making visits to libraries which do not contain the periodical they want or the particular number they wish to consult. The matter was brought to the notice of the Science Committee of the British Medical Association, which recognized the importance of the suggestion and in consequence a small sum of money was voted to cover preliminary expenses. A number of libraries have now been examined under Dr. Leiper's direction and a considerable amount of material collected, which it is hoped may shortly be made available. The manuscript list has been brought up to date and can now, we believe, be consulted at the School of Tropical Medicine.

[1] From the *British Medical Journal.*

THE GORGAS MEMORIAL INSTITUTE

THE American Public Health Association at its fiftieth annual meeting, held in New York City November 14-18, 1921, adopted the following resolution authorizing the president of the association to appoint a committee of five to cooperate with the organizers and directors of the proposed Gorgas Memorial Institute:

WHEREAS, The late William Crawford Gorgas, surgeon general of the United States Army, freed

Havana and the Panama Canal Zone of yellow fever and malaria, thereby saving thousands of lives and making possible the construction of the Panama Canal; and

Whereas, The work of the late General William Crawford Gorgas was an epoch in the field of medical science and a milestone in the work of public health throughout the world, in effect proving conclusively that health, even in the tropics, is a purchasable commodity under scientific guidance and administration; and

Whereas, It is the desire of the American people to join with the peoples and governments of Central and South America in paying tribute to the memory of General Gorgas, and the proposed Gorgas Memorial Institute, which will be erected in the City of Panama, represents the most fitting way to perpetuate the work of General Gorgas and to render the greatest good to humanity, with its possibilities for the saving of tens of thousands of human lives and the making available of hundreds of thousands of square miles of land for inhabitation and cultivation by white people; and

Whereas, The Republic of Panama, in expression of its gratitude to the late General Gorgas, has already donated the site, the building and all necessary equipment for the proposed Gorgas Memorial Institute representing approximately $500,000; there is yet required an endowment fund of from three to six millions of dollars to maintain and to carry on this great work;

Therefore, Be It Resolved, That the American Public Health Association assembled in its semi-centennial convention in the City of New York, November 17, 1921, go on record as heartily endorsing the proposed Gorgas Memorial Institute and that the president of the association be requested to appoint a committee of five to cooperate with the officers and directors of the proposed Gorgas Memorial Institute.

The following members of the committee have been appointed:

W. H. Welch, M.D., chairman, Baltimore, Md.; A. T. McCormack, M.D., Louisville, Ky.; Victor C. Vaughan, M.D., Ann Arbor, Mich.; Professor E. O. Jordan, Chicago, Ill.; M. P. Ravenel, M.D., Columbia, Mo.

THE REORGANIZATION OF MATHEMATICS IN SECONDARY EDUCATION

The complete report of the National Committee on Mathematical Requirements is in the press and will, it is hoped, be ready for distribution in April. It is published under the title "The Reorganization of Mathematics in Secondary Education" and will constitute a volume of about 500 pages. The table of contents given below indicates its general character.

Through the generosity of the General Education Board the National Committee is in a position to distribute large numbers of this report free of charge. It is hoped that the funds available will be sufficient to place a copy of this report in every regularly maintained high school library and also to furnish every individual with a copy free of charge who is sufficiently interested to ask for it. Requests from individuals for this report are now being received. They should be sent to J. W. Young, chairman, Hanover, New Hampshire. Individuals interested in securing a copy of this report are urged to send in their requests as early as possible. If the number of requests received exceeds the number the committee is able to distribute, the earlier requests will receive the preference.

The table of contents of the report is as follows:

Part I

General Principles and Recommendations.

Chapter I. A brief outline of the report.

Chapter II. Aims of mathematical instruction—general principles.

Chapter III. Mathematics for years seven, eight and nine.

Chapter IV. Mathematics for years ten, eleven and twelve.

Chapter V. College entrance requirements.

Chapter VI. Lists of propositions in plane and solid geometry.

Chapter VII. The function concept in secondary school mathematics.

Chapter VIII. Terms and symbols in elementary mathematics.

Part II

Investigations Conducted for the Committee

Chapter IX. The present status of disciplinary values in education. By Vevia Blair.

Chapter X. The theory of correlation applied to school grades. By A. R. Crathorne.

Chapter XI. Mathematical curricula in foreign countries. By J. C. Brown.

Chapter XII. Experimental courses in mathematics. By Raleigh Schorling.

Chapter XIII. Standardized tests in mathematics for secondary schools. By C. B. Upton.

Chapter XIV. The training of teachers of mathematics. By R. C. Archibald.

Chapter XV. Certain questionnaire investigations.

Chapter XVI. Bibliography on the teaching of mathematics. By D. E. Smith and J. A. Foberg.

THE BRITISH COLUMBIA EXPEDITION OF THE UNIVERSITY OF CALIFORNIA

AN expedition sent out by the University of California Museum of Vertebrate Zoology returned from northern British Columbia in the latter part of October. The party consisted of Harry S. Swarth, curator of birds; one assistant, William D. Strong, and local packers. Five months were spent in exploration of the valley of the upper Skeena River and in collecting series of the birds and mammals of the region. Over one thousand specimens were secured.

The summer's work was in continuance of a general plan, under way through a period of years, which has necessitated zoological exploration in various parts of British Columbia and Southeastern Alaska. This work was inaugurated and has been continually supported by Miss Annie M. Alexander, her interest leading her to participate personally in several of the expeditions. It has resulted in the acquisition by the museum of large collections of vertebrate materials and a store of detailed information, much of it new, regarding the animal life of the northwest coast region.

In the localities in which the last two seasons' field work was spent (the valley of the Stikine River in 1919, the Skeena River in 1921), the distribution of animal species is of particular interest. The section represented serves as a meeting ground between the faunas of eastern North America, the Pacific Coast humid strip, and the Yukon region to the northward. It thus affords exceptional opportunities for the study of the geographic behavior of the species involved. Hence, in the field work pursued, stress was laid upon the distribution of species, and collections were made showing the contrasts existing between mountain top and valley, and between coast and interior.

BACHE FUND OF THE NATIONAL ACADEMY OF SCIENCES

DR. HEBER D. CURTIS has been elected a member of the board of directors of the Bache Fund of the National Academy of Sciences in place of Dr. E. B. Frost, resigned. The board is at present constituted as follows: Professor A. G. Webster, Clark University, Worcester, Massachusetts; Dr. Heber D. Curtis, Allegheny Observatory, Pittsburgh, Pennsylvania; and Professor Ross G. Harrison, Yale University, New Haven, Connecticut.

Applications for grants will be considered semi-annually and should be filed with the board not later than April 1 or October 1 of each year.

The following grants have been recently made:

H. Nort, Gouda, Holland, $200. For counting the stars on the Franklin-Adams Charts.

H. S. Jennings, Johns Hopkins University, $300. For a study of the cytology of the rhizopods with relation to the genetics and development of these organisms.

H. M. Evans, University of California, $500. For the investigation of the œstrous cycle in the rabbit and cat.

Carl Hartman, University of Texas, $500. For the study of the œstrous cycle of the opossum.

William Bowie, U. S. Coast and Geodetic Survey, $250. For the work of the Ukiah Latitude Station.

SCIENTIFIC NOTES AND NEWS

FRIENDS of Professor Chandler presented in 1910 to Columbia University a sum of money which constitutes the Charles Frederick Chandler Foundation. The income from this fund is used to provide a lecture by an eminent chemist and to provide a medal to be presented to the lecturer in further recognition of his achievements in science. Previous lecturers on this foundation have been L. H. Baekeland, W. F. Hillebrand, W. R. Whitney, and F. Gowland Hopkins. The lecturer this year will be Edgar Fahs Smith, president of the American Chemical Society, formerly professor of chemistry and provost of the University of Pennsylvania. Dr. Smith's subject will be "Samuel Latham Mitchill—A Father in American Chemistry." Mitchill was the first professor of

chemistry at Columbia College and the first senator from the State of New York. The lecture will be in Havemeyer Hall, Columbia University, on March 2, 1922, at 8:15 P. M.

PROFESSOR THEODORE LYMAN has succeeded the late Professor Charles W. Cross as chairman of the Rumford Committee of the American Academy of Arts and Sciences. Applications for grants from the funds at the disposal of the committee should be made to Professor Theodore Lyman, Jefferson Physical Laboratory, Cambridge, Massachusetts.

DR. WILLIAM T. COUNCILMAN, since 1892 professor of pathology in the Harvard Medical School, and Dr. Harold C. Ernst, since 1895 professor of bacteriology, will retire from active service at the close of the academic year.

THE Ambassador of the United States to France has presented Professor Bergonie with the medal and diploma of the Franklin Institute in recognition of his services to science and more particularly for his apparatus employing electricity in the search for and extraction of fragments of projectiles.

THE American Association of Economic Entomologists, at the Toronto meeting, elected Professor James G. Sanders, director of the Pennsylvania Bureau of Plant Industry, Harrisburg, to be president for 1922.

AT the New Haven meeting of the American Society of Biological Chemists, the officers elected for 1922 were: *President,* Donald D. Van Slyke; *Vice-president,* Philip A. Shaffer; *Secretary,* Victor C. Myers; *Treasurer,* Walter R. Bloor; *Councilors,* Stanley R. Benedict, Harold C. Bradley, Albert P. Mathews; *Nominating Committee,* C. L. Alsberg, G. H. A. Clowes, P. B. Hawk, P. A. Levene, H. B. Lewis, E. V. McCollum, L. B. Mendel, J. R. Murlin, R. T. Woodyatt. The president and secretary of the Biochemical Society are this year the chairman and executive secretary of the Federation of American Societies for Experimental Biology, which will hold its 1922 meeting in Toronto.

IN addition to the election, already noted here, of Professor Henry C. Cowles, of the University of Chicago, as president of the Botanical Society of America, other officers were elected, as follows: *Vice-president,* Margaret C. Ferguson, Wellesley College; *Treasurer,* I. W. Bailey, Bussey Institution; *Secretary,* I. F. Lewis, University of Virginia.

MME. MARIE CURIE on February 7 was elected a member of the Paris Academy of Medicine. It is the first time a woman had been elected a member of one of the French academies. The committee had presented six names as candidates to succeed the late Edmund Perrier. The five men nominated withdrew their names when they found out Mme. Curie's name was on the list, and she obtained 64 votes against 15 blanks.

AT the annual meeting of the Royal Meteorological Society on January 18 the Symons gold medal, which is awarded biennially for distinguished work in connection with meteorological science, was presented to Colonel H. G. Lyons.

ERIC A. LOF, of the power and mining engineering department of the General Electric Company, has been decorated with the Royal Order of Vasa by the King of Sweden, in recognition of services to the Swedish Government.

PROFESSOR C. F. CURTIS RILEY, of the department of zoology of the University of Manitoba, who is carrying on investigations on the ecology and behavior of Gerridæ, has been elected a member of the Zoological Society of Tokyo, Japan.

THE Société Française de Physique, at its last meeting in Paris, elected to its membership Professor L. L. Campbell, head of the Physics department of Simmons College, Boston.

THE board of directors of the American Electrochemical Society has appointed Dr. Colin G. Fink, 101 Park Avenue, New York City, secretary of the society to fill the unexpired term of the late Professor Joseph W. Richards.

OLIVER H. GISH, for the past four years research engineer with the Westinghouse Elec-

trical and Manufacturing Company, resigned on January 1, to become associate physicist in the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.

LOUIS J. TROSTEL, who for the past two years has been stationed at the Pittsburgh Station of the Bureau of Mines, engaged on problems relating to industrial gases and dusts, has accepted a position with the Bureau of Chemistry as assistant chemical engineer. He is engaged on chemical problems relating to explosions from starch and other carbonaceous dusts.

DR. J. H. WHITE has been appointed by the Rockefeller Foundation director of the Mexican commission against yellow fever, to replace Dr. T. C. Lyster, who has resigned.

DR. FLORENCE L. MCKAY, recently assistant director of child hygiene, Children's Bureau, U. S. Department of Labor, has been appointed director of the division of child hygiene of the New York State Department of Health.

DR. HAROLD S. DAVIS has resigned from his industrial fellowship at the Mellon Institute of Industrial Research at the University of Pittsburgh to accept a position on the research staff of the Arthur D. Little Company.

A SERIES of five lectures will be given in the University and Bellevue Hospital Medical College under its Herter Foundation on "Interfacial Forces and Phenomena in Physiology" by Dr. W. M. Bayliss, professor of general physiology, University College, London, beginning on Monday, the twenty-seventh of February, 1922, at 4 p. m. and continuing daily at the same hour at the Carnegie Laboratory, 338 East 26th Street. Dr. Bayliss will deliver the seventh Harvey Society lecture at the New York Academy of Medicine on Saturday evening, March 4, 1922. His subject will be "Vasomotor reactions and wound shock."

DR. EDWIN O. JORDAN, professor of bacteriology in the University of Chicago, lectured at the School of Hygiene and Public Health of the Johns Hopkins University, on "Interepidemic Influenza," on January 30. His lecture is one of the series of the DeLamar lectures on hygiene.

THE schedule for the spring public lectures, to be held at the Brooklyn Botanic Garden at 4 p. m., is as follows:

April 7. The Cultivation of Woodland Flowers: Mr. Norman Taylor, curator of plants, Brooklyn Botanic Garden.

April 14. English Gardens: Miss Hilda Loines, president of the Women's Auxiliary, Brooklyn Botanic Garden.

April 21. American Forests and the Necessity for Regrowth: Professor J. W. Toumey, Yale School of Forestry, New Haven, Conn.

April 28. The Civic Value of Botanic Gardens: Dr. C. Stuart Gager, director, Brooklyn Botanic Garden.

"RESEARCH in Chemistry as related to Medicine" was the subject of an address delivered on February 10 by Dr. Russell H. Chittenden of the Sheffield Scientific School, Yale University, before a joint meeting of the New York sections of the American Chemical Society and the American Electrochemical Society, the American sections of the Société de Chimie Industrielle and the Society of Chemical Industry. The address was followed by a discussion by C. H. Herty, H. T. Bogert and F. P. Garvan.

DR. WILLIAM MCPHERSON, chairman of the department of chemistry at Ohio State University, spoke before the Chicago section of the American Chemical Society, January 20, on his experiences in visiting Italian universities.

A LECTURE on "Dyeing: Ancient and Modern" will be given by Professor A. G. Perkin at afternoon meetings of the Royal Institution on February 16 and 23.

MORTEN P. PORSILD, director of the Danish Arctic station, Disco Island, Greenland, recently delivered lectures at the University of Cambridge on the "Flora of Greenland" and the "Excavations in the old Eskimo culture layers."

PROFESSOR H. E. ARMSTRONG has consented to deliver the first Messel Memorial Lecture at the annual meeting in Glasgow of the Society of Chemical Industry. The medal to be presented to Professor Armstrong will, if practi-

cable, be made from the platinum dish bequeathed to the society by Dr. Messel.

A STATUE of Emil Fischer was recently unveiled on the Luisenplatz, Berlin, opposite the statue of Robert Koch. A bronze bust of the chemist, who died in 1919, was also presented recently to the Chemical Institute by Dr. H. Fischer.

DR. PEARCE BAILEY, of New York City, known for his contributions to neurology and psychiatry, died from pneumonia on February 11 at the age of fifty-six years.

SIR WILLIAM CHRISTIE, astronomer royal from 1881 to 1910, died on January 22, in the seventy-sixth year of his age.

H. J. COTTERILL, for many years professor of applied mathematics in the Royal Naval College, Greenwich, died on January 8, at the age of eighty-six years.

IT is stated in *Nature* that at the recent meeting of the Hull Museums Committee the curator reported that when in London recently he heard that the specimens in the museum at the Royal Albert Institute, Windsor, were in rooms which were required for other purposes, and that there was an opportunity of obtaining the collections. He consequently visited Windsor, with the result that the whole of the specimens are now in Hull, and among them are many valuable additions to the antiquities and geological and natural history series already there. Particular mention may be made of some pre-historic Bronze Age and Stone Age weapons, a large collection of Roman lamps and pottery, Greek vases, and a miscellaneous series of medieval antiquities. Otherwise the objects are such as were to be found in museums of this character in the early part of the last century. A handbook to the collections, written by Mr. J. Lundy, was published many years ago.

It is announced that the first five commercial research fellowships instituted by the executive council of the British Empire Exhibition for competition among the chambers of commerce in the United Kingdom have now been awarded. The successful competitors are the chambers of commerce of London, Glasgow, Norwich, Warrington and Oldham, which will each nominate a fellow. The value of each fellowship is not less than £500, and will include a first-class return ticket to the dominion or crown colony to which the selected candidate will proceed. The subjects of research will be: the best means of promoting inter-imperial trade in a selected staple industry and the methods whereby the British Empire Exhibition can further the interests of this trade. The fellow will further investigate the potential resources in raw materials in the dominion or colony visited and the best means for exploiting them in the mutual interest of the dominion and England, and also report on the measures to be taken to insure that these undeveloped resources shall be adequately represented at the British Empire Exhibition and brought to the attention of interested financial and industrial groups.

A COURSE of six public lectures on the "Current work of the Biometric and Eugenics Laboratories" will be given in the department of applied statistics and eugenics, University College, London, February 15, 22, March 1, 8, 15 and 22, 1922. The order of the lectures is as follows: "Sidelights on the evolution of man: from the knee-joint," by Professor Karl Pearson; "On the inheritance of intelligence," by Miss Ethel M. Elderton; "Scheme of anthropometric measurements in the biometric laboratory," by Dr. Percy Stocks; "The relation of caries in the teeth of school children to health and home conditions," by Mr. E. C. Rhodes; "On the inheritance of certain types of blindness," by Dr. Julia Bell; "On occupational mortality," by Dr. M. Greenwood.

WE learn from the Fisheries' *Service Bulletin* that at the second meeting of the International Committee on Marine Fishery Investigations held recently at Boston, the members present were William A. Found and Dr. A. G. Huntsman, representing Canada, and Drs. H. F. Moore and H. B. Bigelow, representing the United States. D. James Davies, the member for Newfoundland, and Dr. R. E. Coker, one of the members for the United States, were unable to attend. Mr. Davies sent a cablegram indicating that Newfound-

land expected to be in position by next summer to cooperate in collecting the desired statistical information. Pursuant to the resolution adopted at the first meeting looking to uniformity in reporting statistics of the offshore fisheries on the Atlantic coast, the committee adopted a form to be used, beginning with the first of the year 1922, for the recording of data obtained. Another resolution provided for the undertaking at an early date of investigations of the life histories of the cod and the haddock. Subcommittees were appointed for consideration of questions of tagging fish and studying ocean currents by the use of drift bottles. The third Friday in May, 1922, was appointed for the next meeting of the committee, which will be held in Montreal.

IN connection with the establishment of funds for scientific research in Norway, grants have now been made for the following purposes: (1) 8,000 kroner for experiments to be made in connection with the use of acetylene gas as motor fuel; (2) 24,000 kroner for the purpose of investigation of vitamines with special reference to cod-liver oil; (3) 6,000 kroner to examine the possibility of employing calcium carbide as a basis for further manufacture in Norway.

THE *London Times* reports that Dr. Mortensen and Mr. Hjalmar Jensen, Danish biologists distinguished, respectively, in zoology and botany, are leading a small expedition to the Kei Islands, west of New Guinea, where, following the advice of Dutch zoologists, they expect to find a suitable site and to draw up plans for the establishment of a permanent station. The plan was proposed some years ago at a Scandinavian research conference in Copenhagen. The Kei Islands lie on a small area of shallow water above the 100 fathom line, but the ocean floor shelves steeply down to the abyssal depths of the Banda Sea. This natural conformation is favorable to scientific work, for some of the fishes, corals and plants, usually to be obtained only by very deep dredging, are believed to ascend to within easy range. The larger island, Great Kei, is of tertiary formation, with mountains and forests; its bird and insect life will repay intensive study. Little Kei and some of the smaller islands were raised above the sea by volcanic eruption less than a centnry ago, and there is plenty of clean bottom. The islands lie on the Pacific side of Wallace's line, one of the primitive land and ocean frontiers of the globe.

UNIVERSITY AND EDUCATIONAL NOTES

BY the will of Mrs. Dexter Smith, of Springfield, Mass., Wesleyan University receives $150,000.

ONE hundred thousand dollars has been received by the University of California from the estate of E. P. Kraft, to be held in trust for the purpose of creating at the university scholarships to be known as the "Edward Frank Kraft Scholarships." Under the terms of the trust, the scholarships are to be apportioned among the various colleges except agriculture, for which scholarships have previously been provided out of the estate of George H. Kraft.

THE Committee of the University of Cambridge for Geodesy and Geodynamics has reported in favor of the erection and equipment of a two-roomed observation building near the observatory as a first step towards the institution that the committee ultimately aims at to meet the requirements of international geodesy.

CHARLES RUSS RICHARDS, dean of the College of Engineering and director of the Experimental Engineering Department of the University of Iilinois, was elected president of Lehigh University on February 7. Mr. Richards succeeds Dr. Henry S. Drinker, now president emeritus.

THE following appointments are noted in *The Journal of Industrial and Engineering Chemistry*: Mr. James H. Ransom has changed his position as research chemist with the Michigan Smelting & Refining Co., Detroit, Mich., to head of the department of chemistry in James Millikin University, Decatur, Ill. Mr. W. H. Rodebush has been appointed associate professor in charge of the division of physical chemistry, University of Illinois, Urbana, Ill.

Mr. Rodebush was formerly national research fellow at the University of California. Dr. Lansing S. Wells, until recently research chemist with The Barrett Company, Frankford, Philadelphia, Pa., has accepted an appointment as assistant professor of organic and physical chemistry, Montana State College, Bozeman, Mont. Mr. Raymond L. Stehle recently resigned as assistant professor of physiological chemistry in the School of Medicine of the University of Pennsylvania to become associated with the faculty of medicine of McGill University, Montreal, as assistant professor of pharmacology.

D. W. Blakeslee has been granted leave of absence for the school year from his position of electrical engineer with the Jones & Laughlin Steel Co., at Pittsburgh, and is teaching in the Electrical Department of Yale University.

Mr. J. Griffith has been appointed head of the department of agricultural chemistry at the University College of North Wales, Bangor.

Dr. Alfred C. Haddon, of Christ's College, University of Cambridge, has been appointed acting curator of the Museum of Archeology and Ethnology.

DISCUSSION AND CORRESPONDENCE

KENTUCKY AND THE THEORY OF EVOLUTION

Your inquiry concerning proposed legislation against the teaching of evolution in the state university and public schools of the state has been received. In reply I will state that two such bills have been introduced in the house, and one was introduced in the senate. The senate bill was reported unfavorably by the senate committee to which it was referred. The same committee also reported unfavorably a milder substitute forbidding the teaching of anything in these public institutions "inimical to religion," but the senate by a vote of 23 to 12 turned down this latter recommendation of the committee and placed the substitute on the calendar.

The house bill which has passed the committee and been placed on the calendar is much more drastic than either of the bills introduced in the senate. It provides for a fine of "not less than fifty nor more than five thousand dollars, or confinement in the county jail not less than ten days nor more than twelve months" for any "teacher, principal, superintendent, president or other person connected directly or indirectly with such schools or institutions, who shall knowingly teach or permit to be taught Darwinism, Atheism, Agnosticism, or the Theory of Evolution in so far as it pertains to the origin of man."

This proposed legislation is the culmination of an active propaganda against evolution which has been carried on in the state for over a year by a number of the ministers of several of the Protestant denominations. The leader of these is Dr. J. W. Porter, pastor of one of the Baptist churches in Lexington, and judging from the expressions in the Baptist press, he has the backing of a large element in his denomination. He it was who received a letter of encouragement from William Jennings Bryan which he promulgated from the pulpit. From this letter we quote the following:

> The movement will sweep the country and we will drive Darwinism from our schools. The enemy is already fighting. The agnostics who are undermining the faith of our students will be glad enough to teach anything the people want taught when the people speak with emphasis.

On Friday, January 20, Bryan was brought to Kentucky, where he made a number of addresses against evolution. The one at Frankfort was before a joint session of both houses of the legislature. In this he advocated legislation against the teaching of Darwinism and kindred "isms." At the close of his address in Lexington a resolution was presented by Rev. W. L. Brock, another Baptist minister of Lexington, and ruled from the platform to have been passed, in which the general assembly was petitioned to prohibit "the teaching in the state schools of evolution, destructive criticism and every form of atheism and infidelity whatsoever."

In their spoken and written attacks on evolution these advocates of suppressive measures quote largely from two publications issued by

the Bible Institute Colportage Association, Chicago, Illinois. One of these is a booklet of 144 pages by Alex. Patterson entitled "The Other Side of Evolution" and the other is a pamphlet of 24 pages by W. A. Griffith Thomas entitled "What About Evolution?" In these publications the attempt is made to refute evolution mainly by the citation of authority. With respect to well known advocates of evolution, such as Tyndall, Haeckel, Huxley, Spencer, and even Darwin himself, commendably cautious statements, particularly with reference to the *causes* of evolution, are twisted and construed into "fatal admissions" affecting their belief in the *fact* of evolution.

For expressions of positive opposition to the theory, recourse is had mainly to men of science long since dead, such as Murchison, Sedgwcik, Agassiz, Dawson, Etheridge, Virchow and Dana.

Much reliance is placed upon the views of the late George Frederick Wright, who wrote a preface to the booklet in 1903. The latter, however, is cautious in his endorsement and not willing to say "that all the points in this little volume are well taken."

It is from the book by Patterson that Mr. Bryan gets his leg-from-wart, eye-from-freckle, joke which he is so fond of retailing from the Chautauqua platform.

Within the last few days Dr. Porter has issued a pamphlet of 94 pages, entitled "Evolution a Menace," in which after giving considerable prominence by liberal quotation from standard text-books to the fact that all modern authority is against him in the position he takes on evolution, he then attempts to refute it mainly by an appeal to authority as old, or older, than that cited by Mr. Patterson.

His citation from Whewell's "Inductive Sciences," written about 1854, is a case in point. Here he attempts to discredit all geology by a quotation which refers only to a lack of progress in "physical geology" comparable to the progress made in "physical astronomy" up to the time the work was written.

Dr. Porter's main reliance for material from more modern authority with which to overthrow evolution is upon Howorth's "Mammoth and the Flood," and upon the geological jugglings of a certain "Professor McCready Price."

The bill placed on the calendar of the house reads:

KENTUCKY GENERAL ASSEMBLY

1922

House Bill 191—Introduced January 23

By Representative George W. Ellis, Barren County.

An act to prohibit the teaching in public schools and other public institutions of learning, Darwinism, atheism, agnosticism or evolution as it pertains to the origin of man.

Be it enacted by the General Assembly of the Commonwealth of Kentucky:

Section 1. That it shall be unlawful for a teacher, principal, superintendent, president or anyone else who is connected in any way with the public schools, high schools, training schools, normal schools, colleges, universities or any other institutions of learning in this commonwealth, where public money of this commonwealth is used in whole or in part for the purpose of maintaining, educating or training the children or young men or young women of this commonwealth; for such teacher, principal, superintendent, president or other person connected directly or indirectly with such schools or institutions of learning to teach or knowingly permit the same to be taught; Darwinism, Atheism, Agnosticism, or the Theory of Evolution in so far as it pertains to the origin of man; and anyone so offending shall on conviction be fined not less than fifty nor more than five thousand dollars or confined in the county jail not less than ten days nor more than twelve months or both fined and imprisoned in the discretion of a jury.

Section 2. If any school, college, university, normal school, training school or any other institution of learning which has been chartered by the Commonwealth of Kentucky and which is sustained in whole or in part by the public funds of said commonwealth shall knowingly or wilfully teach or permit to be taught, Darwinism, Atheism, Agnosticism, or the Theory of Evolution insofar as it pertains to the origin of man, shall forfeit its charter and on conviction shall be fined in any sum not to exceed five thousand dollars. In all proceedings of forfeiture or revocation of charter, the holder thereof shall be given thirty days notice in which to prepare for a hearing to be attended by its representative or counsel.

The commonwealth or the accused may take such oral or written proof for or against the accused as it may deem it the best to present these facts.

This act to be in full force and effect from and after its passage and approval as provided by law.

Arthur M. Miller
University of Kentucky,
February 8, 1922

RELATIVITY AND STAR DIAMETERS

To the Editor of Science: That Michelson's wonderful measurements on star diameters have a fundamental bearing on Einstein's theory and are capable of affording a more decisive proof of it than even the eclipse experiments does not seem to be yet appreciated. In my former note of March 25th, 1921, I expressed the hope that some one more competent than myself would discuss the subject; but nothing has so far appeared but a short note by Dr. Burns, and as he appears to be under some misconception of the theory, I will, with the Editor's permission, go into it a little more in detail.

Dr. Burns refers to an acceleration in the direction of propagation. But this field has nothing to do with the measurement of the diameter. What we do, virtually, is to divide the star disc F into halves by the diameter, shown as a dotted line, and take the centers of gravity of the two semi-circles as two sources. Obviously a considerable amount of the light will come from the edge, as at E, and all of it, except that coming from the diametric line, will be pulled sideways towards the diameter.

By Einstein's theory light from a source S to an observer O will be curved in the manner shown, since all world lines are warped in the neighborhood of matter. Dr. Burns's statement that there is no warping of the light from the star disc means that light originating from a prominence E on the star would not be warped, while light traveling past it, originating from an outside source S would; which necessitates an ether between F and O; which is contrary to the theory of relativity.

The really important point, which I had hoped to bring out in the discussion, is that a purely gravitational bending, shewn by the dotted line C, is not a mere warping, but a permanent change of path to a sort of hyperbola. If the light bending were a purely gravitational effect, all stars should shew measureable diameters, if above certain dimensions. But they do not appear to do so. As the only two alternatives seem to be gravitational bending or Einstein's theory, this seems to be a definite proof of the theory.

But we need a quantitative discussion, at, as I have said, the hands of men better qualified than myself. Mere guess work is not enough. It is true that the angular effect of the world line warping changes with distance, being twice the gravitational effect, but the amount of warping by the sun is approximately 1½ seconds, while the total angle subtended by Betelgeuse is only 1|30 of this, and Betelgeuse is somewhere around ten million times the size of the sun. A quantitative calculation is necessary, not only for Betelgeuse but also for those stars which shew no measurable disc, to explain the absence of a measurable gravitational bending, if Einstein's theory is not true.

Reginald A. Fessenden

PRELIMINARY NOTE ON THE ETIOLOGY OF POTATO TIP-BURN

During the past two years investigations have been carried on at the Experiment Station of Pennsylvania State College to determine the etiology and specificity of the potato tip burn caused by the feeding of the potato leaf hopper, *Empoasca mali* Le B.

These experiments were in the form of a series of inoculations with aqueous and alcoholic extracts of *E. mali* Le B, and other potato feeding insects. The inoculated plants were exposed to sunlight of varied intensity by the use of glass and mesh cages to determine the role of sunlight in the development of the disease.

The results obtained from these experiments support the following conclusions:

1. Tip burn of the potato plant may be produced by the extract made from macerated nymph or adult, *E mali* Le B. and is transmissible by direct inoculation. This points to the existence of a "specific," either normal or extraneous, transmitted by the leaf hopper as the cause of the disease.

2. The active principle of this substance is most virulent in the nymphal stage of the leaf hopper.

3. This "specific" is present in diseased leaf tissue after infection by the leaf hopper and may be transmitted to healthy plants by reinoculation.

4. This substance is specific and the disease can not be simulated by inoculation with extracts from or by the feeding of insects other than *E. mali*, or by mechanical injury.

5. Sunlight is an important factor in the progress of the tip burn after its inception, but the absence of sunlight does not prevent the disease.

A more detailed account of the experiments supporting these conclusions will be published in the near future.

JOHN R. EYER

PENNSYLVANIA STATE COLLEGE,
STATE COLLEGE, PENNSYLVANIA,
SEPTEMBER 30, 1921

QUOTATIONS

ECONOMY IN PUBLICATION

THERE is no doubt that all our learned Societies are going through times of financial stress, owing to the war. Some of them are able to meet the difficulties by an increase of subscription, but others fear that this would diminish their membership, and thus compensate any estimated gain. Meanwhile, the increased cost of printing admits of no doubts at all, and Government help in mitigation is apparently not to be had—nor is it likely that private benefactions will come to the rescue. It seems eminently undesirable that scientific publication should be permanently diminished in amount, and minor economies in printing are apt to take up valuable time, which might be spent more profitably. We may hope that the cost of printing will not remain at the present high level, so that the future may bring less stress; but, meantime, we have to consider what is to be done *now*. With some hesitation I beg to put forward a suggestion for consideration in the special case of the Royal Astronomical Society, which is undoubtedly at the present moment in sore straits. The suggestion is that we should have an Economical Year as regards printing. For twelve months beginning either in January next (or, if that notice is too short, with the Annual Meeting in February next) let all the Fellows do their best to minimize the printing. There would be a vital difference between adopting this policy for one year and adopting it permanently, which, as already remarked, is strongly to be deprecated.

If the policy is publicly declared, the Society would probably find relief in many directions during the year; thus it could, without misunderstanding, discourage, or actually decline, papers which could be printed elsewhere, especially those coming from abroad. Usually these are more than welcome, but there would be no harm in asking our distinguished fellows and associates in other lands to publish elsewhere *for one year*. Of our own fellows many would welcome the opportunity to use one year rather for consolidating work already done than for pushing on new work. An exception should be made in the case of the younger astronomers, whose early fire should not be checked.

Again, I submit that, while the Annual Report of the Council is a document too valuable to lose permanently, there might be no serious disadvantage in cutting it down to very small proportions for one year—the thread could be readily picked up again in the following year. Here, again, some exceptions should obviously be made, especially the notices of Fellows deceased, a record which can not be intermitted. But observatory reports and most of the notes might be dropped.

The question arises how the meetings of the Society shall be adequately filled if the supply of papers is cut down? And this, of course, is a question which must be satisfactorily

answered if the suggested policy is to be successful. I venture to think that the answer is not difficult: astronomy has been progressing so rapidly of late years that there are many matters, great and small, at which we have only had the time to glance without subjecting them to satisfactory discussion. Important ideas have been laid before the Society and clearly explained, which were so new that the audience was scarcely ready with comments. As one illustration, let me take Mr. Jeans' suggestion that the stellar universe was formerly much more compact, and has since been expanding and scattering. This is an idea which alters profoundly views hitherto adopted and hitherto scarcely questioned. At the time of its suggestion the audience was almost silent, for the simple reason that it was too big a thought to take in at once; but since then time has elapsed and, moreover, Mr. Jeans has published a book. It would be strange if an interesting meeting could not be furnished by the discussion of this new idea.

There are other matters, not on this grand scale, which were passed over quickly, simply because one paper trod on the heels of another, but to which a return could now be made all the more profitably because they have appeared in print.

In further support of this policy I may quote the experience of the Geophysical Society, which has, for a few years past, been holding meetings in the rooms of the Royal Astronomical Society on the lines above indicated. The papers presented have, in general, not been original investigations, but rather accounts of work already published, and the amount of printing has been small.

Doubtless if this policy of an economical year—or, let us call it, without prejudice, a special year—were adopted, other ideas would be forthcoming to furnish the meetings: for instance, we have very rarely had anything of the nature of a conversazione; though the few experiences of this kind have all been most enjoyable. Again, we may remember that there will be a meeting of the Astronomical Union in April next. The April meeting of the R. A. S. might very appropriately be devoted to a preliminary discussion of the topics which will engage the attention of the Union; or the May meeting might be devoted to hearing from the returned delegates their experiences in Rome. We may hope, further, that this meeting of the Union will bring to Europe welcome guests from overseas, who will doubtless be able to interest the Society, as we have already had ample experience on former occasions.

In November or December we may hope for news from our eclipse expedition. Finally, if the cutting down of the Annual Report should leave a blank in the February (1922) meeting, perhaps the Fellows might like to fill it by a full discussion of the present suggestion, which is put forward very crudely in the hope that it may be fully and freely discussed.—From an Oxford Note-Book in *The Observatory*.

SCIENTIFIC BOOKS

Applied Entomology. An introductory text-book of insects in their relations to man. By H. T. Fernald. First edition. New York: McGraw-Hill Book Company, 1921.

The author recognizes a two-fold demand of the agricultural colleges in this country for a text-book of entomology which will give: (1) to those students who desire to specialize in entomology a thorough foundational training in the science; and (2) to those students who intend to engage in practical farming and fruit-growing a general knowledge of the kinds, life histories, habits, and control of insects that are of economic importance. He has succeeded in meeting these requirements to a surprising degree in a book of 386 pages. The author first discusses the position of insects in the animal kingdom, their structure, transformations, the losses caused by them, and the nature and kinds of insecticides in modern use in the control of these persistent pests. Necessarily the discussion of these topics is a brief one being included in less than sixty pages. It seems to us unfortunate that the author did not give in this part of the book a general, though brief, discussion of the nature and importance of the biological control of insects and of the vital and ex-

tensive relations insects bear to many human and plant diseases. The activities of insects as parasites and as carriers of disease organisms are, however, noted here and there throughout the text in appropriate connection with the species concerned.

The remaining pages of the book are devoted to a discussion of the characteristics of the different orders of insects with an account of the life histories, habits, and control of a well-selected list of common, representative, and mostly economic species of each order. The author uses commendable and conservative judgment in recognizing and discussing but twenty-four orders with a brief mention of an additional one, the *Zoraptera*. An economic entomologist often wishes the author had been a little more specific regarding control measures. For example, paradichlorobenzene is briefly mentioned as having "given fair success recently" in the control of the peach-tree borer. This seems hardly an adequate statement in view of the widely successful use of this substance by the Federal Bureau of Entomology and by the New Jersey Experiment Station.

The book is fully illustrated with numerous original photographs and many familiar illustrations. It is certainly preferable to use good familiar figures in a text-book rather than poor original ones but great pains should be taken to reproduce the old figures with distinctness and fidelity. For example, figures 130, 131, 135, and 242 have lost much of their original clearness and detail. Moreover one is apt to be momentarily a bit shocked to find an illustration in a dignified text-book with the legend "Samples of Anoplura greatly enlarged" without any attempt to give the reader an inkling of the species figured. These, however, are small matters.

The book has few typographical errors and closes with an excellent index of twelve pages. Altogether the author has written a well balanced, well arranged text of applied entomology for the beginning student and many teachers will find it very useful with their classes.

GLENN W. HERRICK
CORNELL UNIVERSITY

SPECIAL ARTICLES

HIGH SPEED HIGH VACUA MERCURY VAPOR PUMPS

THE writer has on several occasions[1] described two types of high speed mercury vapor pumps capable of producing exceedingly high vacua in reasonably short intervals of time and yet not demanding of the fore pumps pressures less than .01 to .005 mm. of mercury. These mercury vapor pumps were made of pyrex glass and are still in use.

Since then slight modifications have been introduced which considerably reduce the time required in glass blowing though not altering the speed of either pump or the vacua obtainable. The two types in modified form are shown in Figures 1 and 2, and are each drawn approximately one sixth full size. In Figure

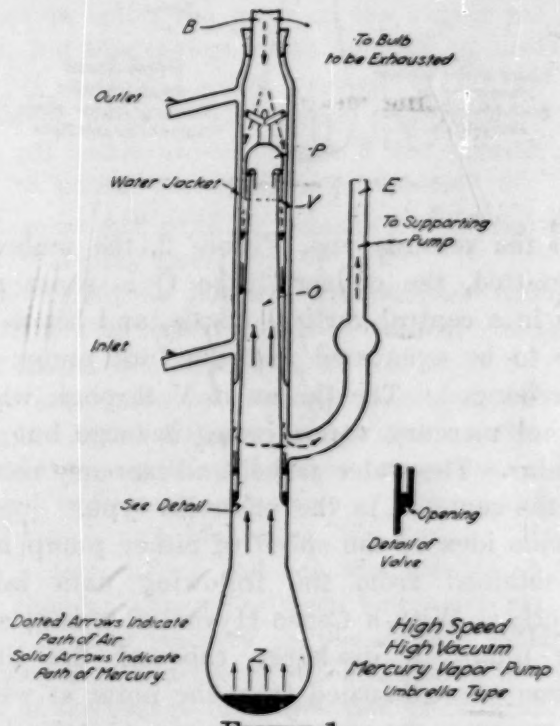

FIGURE 1

1 we have the umbrella type in which the bulb to be exhausted is attached to B, and the supporting pump to E. The hot mercury vapor reaches the umbrella P through the large diameter thin-walled central delivery tube O. The throat at V is large and annular (no central dead space) and hence the issuing mercury vapor comes into immediate contact with the outer water cooled walls. This construction

[1] *Phys. Rev.*, II, 9, 311; 12, 492.

augurs for speed. The water packet is an integral part of the pump. The condensed mercury vapor is returned directly to the boiler through a pin-hole valve shown in the figure.

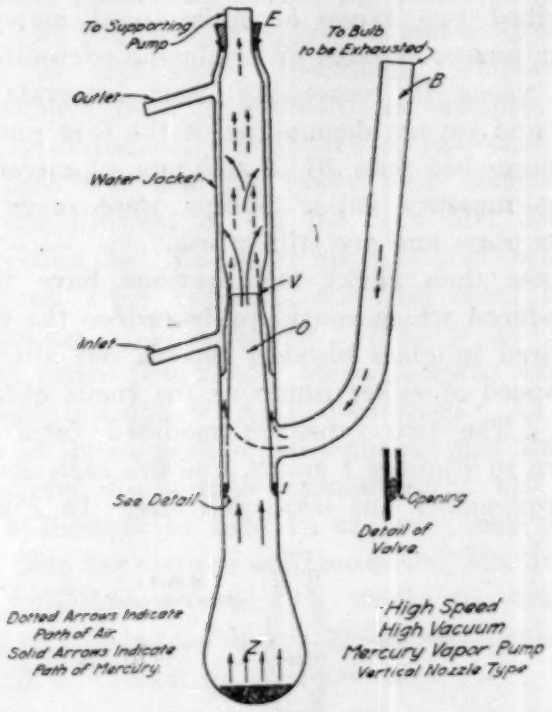

Figure 2

In the second type, Figure 2, the umbrella is omitted, the delivery tube O is short and ends in a central vertical nozzle, and hence the bulb to be exhausted and the fore pump are interchanged. The throat at V through which the hot mercury vapor issues is large but not annular. The water jacket and mercury return are the same as in the umbrella type.

Some idea of the speed of either pump may be obtained from the following data taken recently: With a Cenco-Hyvac oil pump, as a fore pump, a discharge tube of 2.8 liters volume was exhausted from the point at which the mercury vapor pump began to take hold (approximately 1 cm. dark space) to where the tube began to darken (the X-ray stage) in 30 seconds. If a mercury vapor trap is interposed between the pump and B the time in the above may be reduced to 15 seconds or even less!

Comparing the two types it was found that the umbrella type seems, in general, to be the more speedy, possibly for two reasons: first, the water jacket reduces the amount of mercury vapor that finds its way into the bulb B (this of course may be entirely eliminated by the mercury vapor trap mentioned above), and second, the issuing mercury vapor stream is annular. On the other hand the vertical nozzle type is somewhat easier to construct. An advantage of the former, especially for lecture table demonstrations, is that the bulb B to be exhausted is supported centrally over the pump. These pumps are made of Pyrex glass.

Chas. T. Knipp

Laboratory of Physics,
University of Illinois,
December, 1921

THE NEUROMOTOR APPARATUS OF PARAMECIUM

This study which commenced with microinjection experiments on *Paramecium* has led to the discovery of a complex neuromotor system in the animal. This discovery is important because *Paramecium* is a generalized ciliate and yet has attained a degree of structural complexity and functional diversity in respect to one organ system comparable at least with that of the lower Metazoa. It is thus again exemplified that the unicellular state is plainly not an essential condition for evolutionary specialization and functional efficiency, except as it places limits on the size of the organism and the developmental processes arising therefrom.

The neuromotor apparatus consists of a neuromotor center situated near the anterior end of the cytostome and at the posterior end of the oral groove; a set of cytopharyngeal fibers which run from the neuromotor center to the membranelles of the cytostome and cytopharynx; an oral whorl of peripheral fibers which diverge from the neuromotor center and run to the cilia and trichocysts of the oral side of the body; an aboral whorl of peripheral fibers which diverge from the same center to the cilia and trichocysts of the aboral side. The cilia of the organism arise from grooves in the pellicle which run in nearly parallel lines from the anterior to the posterior end of the body. Those on the oral side are slightly oblique, meeting in a series of V's in a line, the oral suture, which runs obliquely through the cytostome from the anterior to the posterior end of the body. The trichocysts are arranged with reference to the neuromotor

system in whorls. They reach the surface of ridges which appear as papillæ because they are cut across at regular intervals by the longitudinal ciliary grooves.

The morphology of this neuromotor apparatus shows that it is well adapted to coordinate the movements of the animal because the organelles of feeding, locomotion, and defense are all connected by a system of conductile fibers to a presumably coordinating center. Furthermore the fibers must be either supporting, contractile, or conductile. Their exceeding fineness indicates the unlikelihood of a supporting function. Their position with respect to the neuromotor center makes it unlikely that they are contractile because those, the main direction of which is longitudinal, would have to operate antagonistically to those whose direction is transverse. The only alternative is that the fibers are conductile.

Three experimental methods, that of staining by micro-injection, the determination of the axial gradient in solutions of narcotics (Child, 1915), and micro-dissection (Taylor, 1920) were used to secure additional evidence pointing towards a neuromotor function of the fibers.

Experiments with the first method were negative. An axial gradient was easily demonstrated, indicating the presence of conductile elements. A high rate of metabolism in the region of the neuromotor center could not be demonstrated, however, because *Paramecium* did not disintegrate as do annelid worms and planarians in the solutions used.

Cutting the cytopharyngeal fibers resulted in the loss of coordinated movement of the cytopharyngeal membranelles. Extensive destruction of tissue in the region of the neuromotor center resulted in the loss of coordinated movement of locomotor organelles. Equal destruction of tissue elsewhere in the body did not destroy coordinated movement.

Thus, while experimental evidence is less conclusive than the morphological it supplements the latter in demonstrating that the fibers of *Paramecium* have a conductile function.

CHARLES W. REES

ZOOLOGICAL LABORATORY
UNIVERSITY OF CALIFORNIA

THE AMERICAN CHEMICAL SOCIETY

(Continued)

SECTION OF LEATHER CHEMISTRY
John Arthur Wilson, *chairman*
G. D. McLaughlin, *secretary*

Color measurement of vegetable tan liquors: HENRY RICHARDSON PROCTER.

The color value of a tan liquor as a function of the hydrogen-ion concentration: JOHN ARTHUR WILSON and ERWIN J. KERN. The color value of a tan liquor depends upon its hydrogen-ion concentration when used. A change in pH value produces a change in color of both liquor and leather. Tan liquors change in color like indicators with change in pH value, but over a range of from 3 to 12. This change in color is completely reversible, if the liquors are not long exposed to air. Liquors exposed to air continue to darken in color, the more so the higher the pH value, but this change is not reversed by lowering the pH value. Liquors exposed to air at pH values of about 9 give bulky precipitates when their pH values are brought to 3 and such liquors tend to poison the hydrogen electrode.

Chemical and physical behavior of gelatin solutions: JACQUES LOEB.

The equilibria between tetrachrome collagen and liquors of different chrome content: ARTHUR W. THOMAS and MARGARET W. KELLY.

The adsorption of the constituents of chrome liquor by hide substance during nine months contact and the equilibria between tetrachrome collagen and various concentrations of liquor: ARTHUR W. THOMAS and MARGARET W. KELLY. Previously a tetrachrome collagen was considered the most complex chrome collagen compound obtainable. In this research an octachrome collagen was prepared. Further it was established through study of the change in composition of tetrachrome collagen in contact with liquors of different concentrations over a period of nine months that the reactions taking place in chrome tanning are chemical in nature. This paper is one of a series of contributions from this laboratory establishing the chemical nature of the combination of chromium with hide to form chrome leather.

Influence of sodium chloride, sodium sulfate and sucrose on the combination of chromic ion with hide substance: ARTHUR W. THOMAS and STUART B. FOSTER. Until four years ago it was considered that the only important features involved in the use of chrome liquors in chrome tanning was the percentage of chromium and

sulfuric acid and their ratio one to another. The researches by Wilson and Kern, of Milwaukee, and by this laboratory have demonstrated that many simple substances hitherto considered without any influence may have a profound effect on the process of chrome tanning. In this research effects of the substances mentioned in the title have been carefully studied and a chemical theory has been propounded which involves the formation of addition compounds. The recognition of the existence of such compounds will be required for proper control of chrome tanning.

Differentiation between physical mixtures and chemical compounds: JEROME ALEXANDER.

Effect of acidity upon the rate of diffusion of tan liquor into gelatin jelly: JOHN ARTHUR WILSON and ERWIN J. KERN. As ordinarily used in tanning, gambier and quebracho extracts show marked differences in the rate of tanning and of penetration into the hide. It is shown that the rate of penetration is a function of the hydrogen-ion concentration as well as of the nontannin content. A sample of gambier penetrated the jelly only at pH values above 3.0, but a sample of quebracho only at pH values above 4.7. Above 9.0 the quebracho penetrated more rapidly than the gambier. The shape of the interface between a tan liquor and gelatin jelly was also found to be a function of the hydrogen-ion concentration.

Theory and use of electrometric titrations: HAROLD FALES.

The chemical constituents of skin: F. L. SEYMOUR-JONES. Animal skin consists of proteins, fats and mineral salts, but for the tanner only the former are of much importance. Proteins occur in nature in the colloid state, a state of matter hitherto somewhat obscure in that it appeared impossible to apply normal chemical laws thereto. Professor Procter, of Leeds, and his collaborators, in particular Mr. J. A. Wilson, for many years studied the swelling of gelatin in acids and finally succeeded in showing that it followed a definite course which could be represented by mathematical expression. Dr. Loeb, of the Rockefeller Institute, has carried this further in studying the effects of different acids, alkalies and salts on gelatin and other proteins, and has shown that, taking into consideration the hydrogen-ion concentration (hitherto neglected), proteins really follow ordinary chemical laws. Of the proteins of hide, the most important is collagen, which is undoubtedly closely allied to gelatin. Elastin is most stable, but for light leathers is generally removed in the bating process. It is highly elastic under very small stresses. For keratins the tanner has little use, and their removal is one of his objects. The interfibrillary cementing substance is usually removed in liming; it is probably a mucoid, but its exact nature is still doubtful. A thorough knowledge of the chemical constituents of skin is essential if progress is to be made in the science of tanning. So far progress has been slow in this direction, but each advance materially aids in increasing knowledge and possibilities of further advance.

The warble fly problem: ALFRED SEYMOUR-JONES. The warble fly is one of nature's pests, ruining hides by its numerous perforations. The fly lays its eggs on the hairs on the legs of cattle; from here the maggot hatches and bores into the animal's body. In order to prevent or cure this plague, the English, Scottish and Irish agricultural authorities set up a scientific committee to deal with the question. Squeezing the warble bots out of the backs of a herd of isolated cattle during five years proved successful, but this would scarcely be feasible on a large scale. Next a mixture of bird lime material and birch tar oil was painted on the hind quarters of some cattle, but, though this might have prevented the flies from laying their eggs, the cattle's tails stuck to the tacky material and they stampeded. A great variety of mixtures, to be applied to the cattle's backs when the maggots are nearly ready to emerge, have been tried. Some give 80 to 96 per cent. kills, but the work is as yet incomplete. However, applied to *all* cattle in an area for two or three years, there is reason to hope that the fly might be exterminated.

Properties and action of enzymes in relation to leather manufacture: J. T. WOOD. Enzymes do not merely accelerate a change already in progress, but actually cause it. An explanation is given of Armstrong's view of the two-fold action of enzymes. The action of hydrolytic enzymes is caused by the increase of hydrogen-ion or hydroxide-ion concentration at the surfaces of their particles. The action of enzymes in the various processes of leather manufacture was discussed. In the "soaks" enzymes are secreted by a variety of species of bacteria, as is also the case in the "limes," but the possibility of the presence of tissue enzymes in these two processes should not be overlooked. The enzymes of the dung bate are then enumerated and a short account of the introduction of commercial enzymes is given. The action of tryptic enzymes on the elastin of the grain and Wilson's experiments are briefly discussed together with the author's views

of the interpretation to be put upon the results. In the "drenching process" the presence of an amylolytic enzyme is essential. Starches are transformed into dextrin and glucoses, which are subsequently fermented into organic acids.

A critical study of bating: JOHN ARTHUR WILSON and GUIDO DAUB. A critical study of bating limed skins in the tannery has been made which tends to elevate a heretofore mysterious process to a scientific plane. The primary function of bating is to remove elastin fibers from the skin prior to tanning. This is done by means of pancreatin after liming, unhairing and washing the skins. When a dilute solution of pancreatin was employed, complete digestion of the elastin was effected only when the pH value of the solution lay between 7.5 and 8.5, but when a more concentrated solution was used, the active range was extended to 5.5 to 8.5. An explanation of this is given on the assumption that an addition compound between the enzyme and collagen is formed in increasing amounts as the pH value is reduced from 8. The rate of removal of elastin from calfskin is shown as a function of the concentration of enzyme and of the time of digestion. Ammonium chloride shows an activating effect in concentrations up to 0.5 gram per liter and a marked inhibitory effect in higher concentrations. The failure of commercial bates to remove elastin from calfskin was attributed to the presence of woody fibers. A comparison of bated and unbated leathers was made. The work was illustrated by five photomicrographs and four sets of curves.

The microscope as applied to leather manufacture: FINI ENNA.

The isoelectric point of collagen: ARTHUR W. THOMAS and MARGARET W. KELLY. Recent expemental work in biological chemistry has demonstrated that proteins are amphoteric electrolytes in aqueous solution. The point of transition in their amphoteric properties is known as the isoelectric point, a knowledge of which is essential in interpretation of their chemical and colloid chemical conduct. Hides and skins consist of proteins, the protein collagen predominating. It is obvious that the amphoteric nature of hide protein plays an important rôle in tanning the hide. The object of this research was to determine the isoelectric point of hide protein and thus contribute to the chemical control of leather manufacture. The experiments enumerated in the paper show the isoelectric point to be at a hydrogen-ion concentration of 10^{-5} moles per liter. At acidites higher than this, the hide is electropositive and at lower acidities, or greater alkalinities it is electronegative.

Physiological and histological observations on the flayed skin entering into the art of leather manufacture: ALFRED SEYMOUR-JONES. Before proceeding with the animal skin, the tanner first removes all the hair and outer skin (epidermis) from the outside and all adhering fleshy matter from the inside of the skin. This leaves the true skin to be converted into leather. This true skin consists of four distinct layers. The topmost layer is the grain membrane, which varies considerably in feel and texture with different animals. It forms a connecting link between the epidermis and the true skin. Just below it lies a thin layer, the *cutis minor*, vitally important in the manufacture of good leather. Below again is the fatty layer, largely consisting of groups of fat cells, resembling in appearance bunches of grapes. The last layer is the *cutis major*, which forms the major part of the whole skin. It is composed of white collagen fibers, intertwining in every direction to form a firm and inextensible coat for the body. In the grain membrane and *cutis minor* the white fibers are supported by yellow elastic fibers. When, as in bating, the elastic fibers are removed, these two layers become soft and extensible, and the skin "falls." This is the result desired in the preparation of glove leathers, kid, and the like. But it is only necessary to bate these two upper layers. Since there is no elastin in the two basal layers, bating these latter only causes loss of valuable skin substance without any corresponding benefit.

The chemistry of lime liquors used in the tannery: W. R. ATKIN. The author has extended the theories of Procter and Wilson and of Loeb to the alkaline swelling of hide in lime liquors. The real reason why such sharpening agents as sodium sulfide and sodium carbonate produce greater swelling than lime alone is that the osmotic pressure which causes swelling is greater for sodium collagenate than for calcium collagenate at the same pH value. The smooth grain of skins unhaired in limes containing arsenic sulfide is due to the fact that calcium collagenate only is formed. A rapid method for controlling lime liquors is described. Alkaline swelling is shown to be exactly analogous to acid swelling, which has been more extensively investigated. Certain tanning processes are shown to act in a way parallel to pickling.

The determination of tannin: JOHN ARTHUR WILSON and ERWIN J. KERN. The authors have succeeded in improving the procedure of their